4. Capabilities for Developing U.S. Population Scenarios

The need for population projections that span demographic variables, time frames, and geographic scales is as great—and diverse—as the communities that use these projections. The workshop participants focused not only on what user needs were (as presented in Section 3, above), but also on what our scientific capabilities are to meet those needs. The discussion in the workshop report thus far has used "projection" as a somewhat generic term characterizing a population future. In reality, different users may have needs for different types of futures. For example, some users may rely on predictions that seek to answer a question of the type of "What will happen in the future?" while others may rely on projections that are more in the nature of "what if" statements, and still others may use scenarios identifying plausible descriptions of future states of the world. The discussion below distinguishes between these types of futures, and discusses the relationship among different types of future characterizations.

In discussing capabilities, participants and presenters identified a number of difficult challenges, stemming both from the diversity of needs, and from the difficulty of understanding and quantifying the pathways by which socioeconomic and other variables influence changes in populations. As that understanding improves, researchers may become better able to reduce the uncertainty and improve the reliability of projections. One presenter highlighted these issues by looking at what scholars in the 1930s would have needed to project U.S. migration trends (see Text Box 4-1).

Text Box 4-1. Backcasting to 1939: A Lesson in Humility

The story of migration patterns for the last 100 years or so is persistence—e.g., fast-growing places tend to remain fast growing and vice versa. The biggest driver of this persistence appears to be natural amenities (climate, landscape, nice places).

Yet, scholars of the late 1930s would have thought "people follow jobs" not: "jobs follow people." They would not have understood key drivers in current U.S. migration trends, such as:

- Innovation in public health and air conditioning
- Congestion that closes off city growth
- Rise of information technology on the West Coast
- Pro-business policies in the South after WWII

Source: Partridge, 2014.

This section reports on the discussions that occurred during the workshop as participants tackled this issue from three perspectives: (1) future characterization (how do we define and integrate different approaches to developing projections and scenarios), (2) the context for U.S. scenarios that global scenarios and global demographic changes (e.g., migration) provide, and (3) the "state of the science" and current capabilities to meet diverse user needs. The last subsection then revisits the question of "capabilities," identifying not only where we have the models and tools we need, but also areas where new tools or sources of data are needed.

Characterizing the Future: Projections and Scenarios

Analyzing the anticipated effects of policies, programs, and environmental change and other conditions requires a view of what will happen in the future. Different uses may require different types of population futures (Smith et al., 2013). In some cases, a qualitative statement of trends and expected changes in key drivers suffices for planning or analytical purposes. In others, quantitative population projections will be needed; these projections can be deterministic, or may be probabilistic or stochastic. For some decision making purposes, projections can be used to conduct "what if?" analyses, allowing researchers to consider the determinants of population change. Projections can also take the form of scenarios; when there is considerable uncertainty about the future, alternative scenarios can be used to explore the effects of different assumptions about the future.

The IPCC has developed a typology of terms for describing future characterizations, including scenario, storyline, projection, and probabilistic futures (see Text Box 4-2). The terms reflect typical usage in climate change impact, adaptation, and vulnerability (CCIAV) studies (Carter et al., 2007). They describe a range of approaches to describing plausible futures, with one key difference among the approaches being the extent to which probabilities are ascribed to the future.

Text Box 4-2. IPCC Definitions of Future Characterizations

Some key terms from the IPCC typology are defined below. More information is available from the IPCC reports.

Scenario is a coherent, internally consistent, and plausible description of a possible future state of the world, which may be quantitative, qualitative, or both. The components of a scenario are often linked by an overarching logic, for example a *storyline* that represents a qualitative, internally consistent narrative of how the future may evolve.

Storylines describe the principal trends in key drivers and relationships among these drivers. Storylines may be stand-alone, but more often underpin quantitative projections.

Projection is any description of the future and the pathway leading to it. In the climate world, projections are often model-derived estimates of future conditions for an element (such as population) of an integrated system. Projections are generally less comprehensive than scenarios. Projections may be probabilistic, while probabilities are not ascribed to scenarios.

Probabilistic futures are futures with ascribed probabilities. Conditional probabilistic futures are subject to specific underlying assumptions. Assigned probabilities may be imprecise or qualitative, as well as quantitative.

A *prediction or forecast* is a statement that something will happen in the future, based on what is known today, and on the initial conditions that exist. An important part of a prediction is our degree of belief that it will come true.

Sources: Carter et al., 2007, Solomon et al., 2007. Weaver et al., 2013.

A projection is not the same as a prediction. A prediction is an attempt to produce an estimate of the actual evolution of the future and is usually probabilistic in nature. A prediction assumes that the future outcome will not be greatly influenced by unpredictable or uncertain future conditions. A projection, in contrast, specifically allows for significant changes in the conditions that might influence the prediction, creating "if this, then that" type statements. Thus, a projection is a statement that it is possible that something will happen in the future if particular conditions (e.g., socioeconomic and technological developments) are realized. A projection is, therefore, subject to substantial uncertainty.

One of the presenters referred to the following IPCC graphic (Figure 4-1), which maps the approaches to characterizing the future described in Text Box 4-2 (among others) into the space

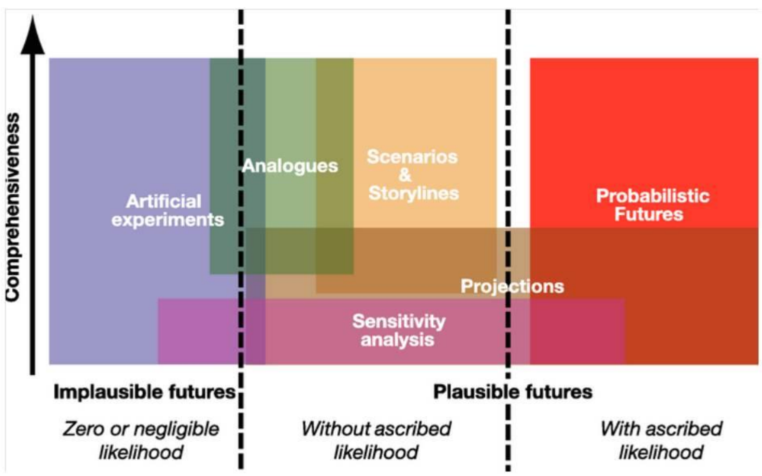


Figure 4-1. Characterizations of the future

Figure Source: Carter et al., 2007.

defined by the dimensions of comprehensiveness and plausibility. Comprehensiveness indicates the degree to which the characterization possesses the variety of population attributes (and the level of detail for each attribute), needed by the user community. Plausibility indicates a subjective assessment of whether a characterization is possible; implausible futures are assumed to have zero or negligible probability. As indicated on the graphic, scenarios typically are more comprehensive than projections, because of the greater number of elements they include in describing the future state of the world. However, projections, unlike scenarios, are sometimes assigned probabilities.

One of the issues prominent during discussions was the difference between projections and scenarios, and the type of approach that best serves different user communities. Participants from the climate change community, for example, described an approach that focuses on building alternative plausible futures and quantifying the outcomes for relevant elements of the scenarios. The scenario approach is preferred by researchers and analysts looking at climate change because it reflects the greater uncertainty about the future over the long term and the importance of assumptions about key variables, including climate policies, economic growth, technological change, and migration patterns.

According to presenters and discussants, many state agencies prefer a single projection series on which to base policy and programmatic decisions; consequently state demographers may have their projections interpreted as predictions, in the sense of representing a most likely outcome, rather than a conditional statement about the future, driven by scenarios, storylines, or other assumptions. In many cases, the discussion indicated that the development of alternative projections by demographers is less a reflection of alternative visions for the future than an intention to bracket the uncertainty in the projection.

In practical applications of projections to state and local policy issues, the divergence between a scenarios approach and a projection approach is not always as great as the above discussion might imply. State and local planners and other public officials may use scenario building, or scenario-based planning, as a systematic approach to understanding current and emerging trends that are shaping the community, with a goal of developing a reasonable, plausible population projection for a community. For example, Franklin County in Florida developed a population growth scenario outlining the type of growth expected in the county and identifying the facts driving growth in the community. The scenario that was then utilized in the preparation of a population forecast for Franklin County (see Text Box 4-3; Chapin and Diaz-Venegas, 2007).

Text Box 4-3. A Population Growth Scenario for Franklin County, Florida

Franklin County developed a growth scenario through the year 2030, using interviews with local experts, reviews of planning documents and print media, and analysis of population and economic data for the county, the region, and the state.

Developing a plausible scenario involved gathering data and trends in key factors, including:

- Dimensions of growth, including historical population growth, emerging development trends, and part-time residents;
- Factors driving population increases, including continued growth of the state and region, and public and private efforts to create regional branding for the Florida Panhandle, and the location of a new state prison; and
- Factors limiting population increases, including infrastructure issues, public land holdings, and county culture.

Source: Chapin and Diaz-Venegas, 2007.

Similarly, some users employ “visioning” to develop different futures on which the projections are based, or bracket possible futures to reflect uncertainty in key drivers. Planning using scenarios may involve an iterative process of defining the vision; coming up with different scenarios that articulate the vision; evaluating, refining, and identifying top priorities; and the turning the findings into an actual plan, typically working with stakeholders like residents and businesses throughout. Envision Utah, for example, works with communities throughout Utah to engage residents in the planning process (see Text Box 4-4). Alternatively, scenarios may be developed that represent aspirational goals, or reflect different policy scenarios (e.g., changes in zoning rules).

Discussions and presentations at the workshop clarified some of the misunderstandings between different groups regarding the differences between projections and scenarios, and highlighted the usefulness of a scenario approach in developing conditional projections. Nonetheless, many of the demographers at the meeting continued to express significant reservations about making long-term demographic projections, especially for small areas. It will be particularly important to provide content and guidance for appropriate use and limitations of such projections.

Text Box 4-4. Envision Utah's Process

Envision Utah uses interviews, mapping exercises, surveys and other means to hear from residents and uses that information to present different community scenarios based on the information gathered. Residents react to the scenarios and choose the future that best matches their vision. Based on public input, Envision Utah's voluntary recommendations for achieving that vision respect private property rights and are grounded in the realities of the local market. Local elected officials, along with residents, have the opportunity to implement the public's vision as they best see fit.

Source: Envision Utah, 2014.

Global and Societal Contexts

Complications are inherent in developing population scenarios that will meet the diverse user needs for climate change analyses and other uses of population projections, articulated in Section 3 of this report. One set of issues surrounds the nature of global scenarios, which are used extensively in the climate change arena, and may inform—but also can complicate—the process of developing U.S. scenarios. At the workshop, participants explored existing global scenarios and what it would mean for U.S. scenarios to be consistent with these scenarios. Participants also explored how societal considerations and context add another layer of complexity to the process of defining desirable characteristics for U.S. population scenarios. Key discussion questions and responses are summarized below; these reflect the tenor of the dialog among participants.

A broad range of global scenarios is available for use in the CCIAV studies, including the Special Report on Emissions Scenarios (SRES), the Shared Socioeconomic Pathways (SSPs), the Representative Concentration Pathways (RCPs), and scenarios developed for the Millennium Ecosystem Assessment. These scenarios can be used in global assessments and other studies, such as the Millennium Ecosystem Assessment and the IPCC's Assessment Reports. The scenarios are generated from a set of assumptions about the future, and common drivers include economic development, population growth, technological development, attitudes toward environmental protection, and globalization (Moss, 2014).

One of the most widely used sets of scenarios are the so-called "SRES" scenarios, which were developed for the CMIP and have been the mainstay in climate assessments for more than a decade (Nakićenović et al., 2000). This SRES framework includes four storylines that extend to 2100, each of which is defined along two dimensions: environmental/economic patterns of growth, and globalization vs. regionalization.

The SSPs are a new scenario framework being developed that includes five separate narratives or storylines (see Figure 4-2). These SSPs are designed to be used in conjunction with the RCPs. The RCPs are a set of four scenarios containing GHG emissions, GHG concentration, and land-use pathways that are driven by underlying scenarios of socioeconomic variables, land-use and land-cover factors, and GHG emissions. The RCPs were developed by selecting and updating scenarios described in the existing literature, and then harmonizing and downscaling emissions and land-use data (van Vuuren et al., 2011). The SSPs are being developed as part of a parallel process to link climate modeling, integrated assessment modeling, and impacts, adaptation, and vulnerability modeling. They represent more detailed socioeconomic pathways that can be used to explore uncertainty in terms of the socioeconomic challenges to mitigation and adaptation shown along the two axes in Figure 4-2. The ways in which different SSPs may be linked to the RCPs are demonstrated in Figure 4-3. Participants pointed out that researchers are already using the SSPs, although many still use the SRES. In addition to the scenarios being designed for purposes of climate change work, scenarios have been developed for the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) and for the UNEP Global Environmental Outlook (UNEP, 2012), as described in Text Box 4-5.

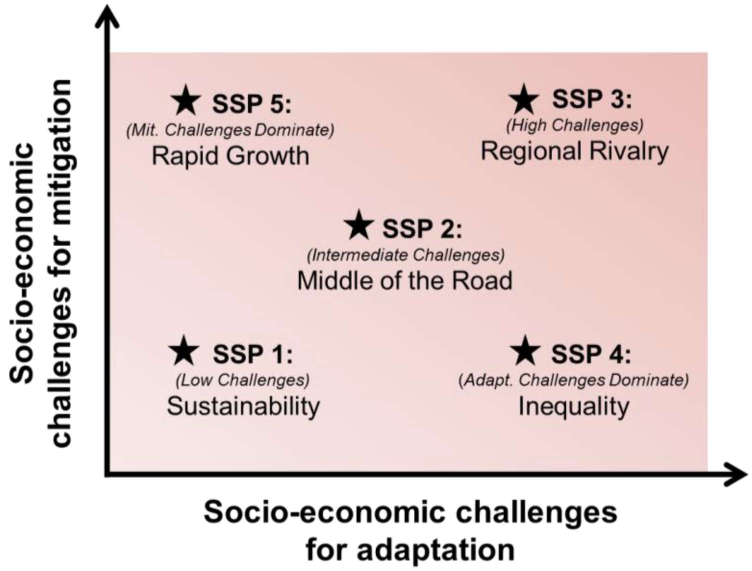


Figure 4-2. Qualitative descriptions of the SSPs

Figure Source: O'Neill, 2014b.

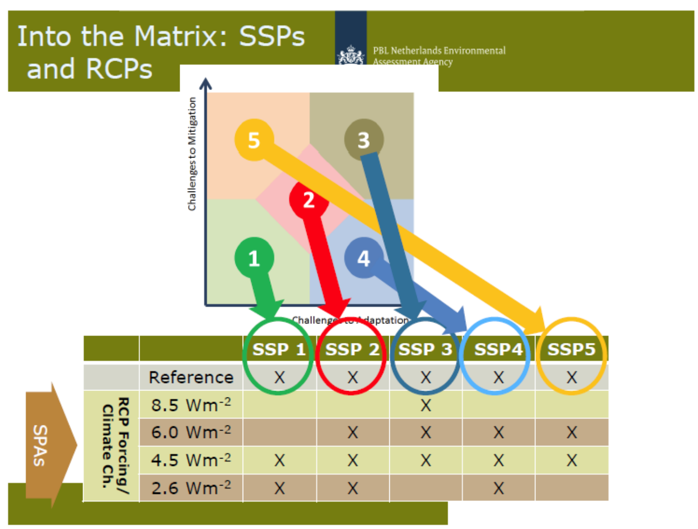


Figure 4-3. A crosswalk of the SSPs and the RCPs

Figure Source: Kram, 2012.

In some cases, alternative population projections have been developed to be consistent with scenarios, such as those developed by the IPCC (Nakićenović et al., 2000). For example, the USGS of the Department of the Interior developed population scenarios to predict land use and land cover changes, as well as disturbances to ecosystems in different geographic areas in the United States. These scenarios were developed to be consistent with the qualitative IPCC storylines.[6] Similarly, EPA's Integrated Climate and Land-Use Scenarios (ICLUS) provide detailed population and land-use scenarios that are also broadly consistent with the IPCC storylines. The scenarios are modified by adjusting assumptions about fertility, international and domestic migration, household size, and travel time to the urban core. Scenarios, rather than deterministic population projections, are particularly important for analyses involving climate change because of the very long time frame of the analysis, the close linkage between different population metrics and impacts, and the heterogeneous nature—spatially and temporally—of climate-related hazards and demography.

Text Box 4-5. UNEP Global Environmental Outlook

The UNEP GEO provides another view of global scenarios. While the SRES and SSP scenarios represent pathways in the absence of explicit climate change policies, the GEO produces two storylines (to 2050): one follows a business-as-usual trajectory, and the other follows a path driven by global goals and targets for environmental, social, and economic sustainability.

Source: UNEP, 2012.

Participants at the workshop discussed the possibility—and importance—of consistency between the national and existing global scenarios, such as the SSPs (see Text Box 4-6). Some stressed that although consistency is important, it should be defined loosely. This viewpoint stressed the importance of consistency of U.S. scenarios with the underlying concepts reflected in global scenarios, rather than the quantitative aspects (e.g., U.S. EPA, 2009; Jiang, 2014). More generally, efforts to maintain consistency should not overly constrain or limit the suite of plausible national U.S. scenarios. Others pointed out that the size and heterogeneity of the United States fosters internal tensions and factors that may not be addressed by the SSPs or other global

Text Box 4-6. The Quantification of the Shared Socioeconomic Pathways (SSPs)

The SSP database aims at the documentation of quantitative projections of the Shared Socioeconomic Pathways (SSPs). The database includes quantitative projections for population (by age, sex, and education), urbanization, and economic development (GDP). These quantitative elements have been developed by collaboration among different groups, including the International Institute for Applied Systems Analysis (IIASA), the National Center for Atmospheric Research (NCAR), the Organisation for Economic Co-operation and Development (OECD), and the Potsdam Institute for Climate Impact Research (PIK).

Source: Jiang, 2014. For additional information see also: http://www.iiasa.ac.at/web/home/research/researchPrograms/Energy/SSP_Scenario_Database.html.

[6] Detailed background information on the IPCC storylines is available at: www.ipcc.ch/ipccreports/sres/emission/index.php?idp=3.

scenarios; consequently U.S.-specific variants or place-specific conditions could lead to storylines that are qualitatively different from global storylines, as well. Still others pointed out that the notion of "consistent" scenarios does not mean the same thing for all types of analyses; some analyses can selectively focus on characteristics that are important for its framing. For example, different aspects of a storyline may be more important for framing a mitigation analysis, while others are critical to impacts and adaptation.

When the underlying concepts supporting scenarios at the national level are consistent with the concepts driving global scenarios, national scenarios can be further tailored to reflect nationally relevant factors. Participants pointed out that migration is one factor driving population scenarios that may manifest differently at the national scale than at the global scale. Some noted that internal migrations may not mirror global migrations; connections exist, but they are poorly understood. Understanding migration patterns in the United States is important for understanding national population distribution, population changes, and rates of population change along the urban-rural continuum. As mentioned in Section 3, users have expressed an interest in having the flexibility to consider different population scenarios that reflect an array of migration patterns.

The second broad type of complication arises from the socioeconomic and societal context within which scenarios and projections are developed. Participants at the meeting identified important categories of non-demographic factors, including governance, and education. They also pointed out that abandonment is less well understood than development. With respect to migration, the discussion identified a number of factors that can drive migration, including housing, zoning, transportation, air quality, gasoline prices, taxes, short-term and long-term economic change, environmental change, land availability, and human behavior. One presenter pointed out that migration patterns in the United States for the past 100 years or so have been remarkably persistent; fast-growing places tend to remain fast growing, and vice versa (Partridge, 2014). The presenter shared tables and maps suggesting that the biggest driver of this persistence appears to be natural amenities (climate, landscape, and nice places). He argued that, while demographers often assume that people follow jobs, in fact the reverse may be true, and jobs follow people.

Available Data, Methods, and Tools

A variety of tools, data, and methods are available to develop projections that incorporate different population attributes, and different levels of spatial and temporal detail. In applying these methods, the user community often faces tradeoffs; some variables (well-understood variables such as age, race, and sex) will be relatively easy to project at the national and sub-national level, but become more difficult as the geographic unit or scale shrinks. The sub-county level can be particularly difficult to work with, especially for less well-understood variables, such as education. Reconciling estimates for different geographic scales can also be difficult; while statewide growth rates, for example, will influence growth rates in many communities, population changes in local communities will also be governed by many highly local factors, such as development patterns and building plans. Applying existing models, collecting important data, and developing new techniques will all be part of developing population projections to suit a variety of purposes, as well as turning the type of qualitative and quantitative scenarios that are discussed above, into quantitative population projections.

Presentations at the workshop addressed the types of methods that are available to project population at the national and subnational levels, and the strengths and weaknesses of different methods. When developing aggregate national projections that require only core demographic variables (e.g., population by age and sex), the cohort-component technique remains a useful and common approach, as various presenters noted (Balk, 2014; Murdock, 2014; Smith, 2014). Different scenarios can be developed by modifying the rates of change, particularly assumptions about fertility and international migration. However, when a set of projections needs to include socioeconomic variables or spatially explicit information, the cohort-component technique cannot be used alone. It cannot easily be used to project non-demographic variables, nor can it be used to project internal migration, which is critical to spatially explicit projections (Balk, 2014).

As the requirements for a set of projections grow more complex, other methods may be used alone or in combination with one another. Some methods, such as proportional scaling make it possible to develop spatially explicit projections or to incorporate additional demographic detail. Scaling can also help address lack of fine-scale data, while also ensuring consistency between the small scale and aggregate totals (Jones, 2014). Trend extrapolation can be used to develop projections based on a curve fit to historical observations, particularly for variables such as educational attainment, where historical trends can be observed (Balk, 2014; Jones, 2014; Smith, 2014). Other large-scale approaches can address some of the complexities; for example gravity-based approaches can be used to project spatially explicit rates of change; however, while this approach can capture geographic suitability and population counts, it cannot provide demographic or socioeconomic detail (Balk, 2014; Jones, 2014).

These and other models—such as structural models and microsimulation models—provide additional information, but also are data intensive. Consequently, they may be appropriate for projections that are national in scope, yet require spatially explicit detail. Structural models, which project demographic changes based on causal relationships between demographic and non-demographic variables, provide an opportunity to explore the impact of non-demographic drivers on various scenarios. At the same time, these methods do not handle demographic processes, such as fertility and mortality, as easily as the cohort-component method, so hybrid approaches are being used to gain the advantages of different techniques.

Scaling and extrapolation techniques are often used on the sub-county level due to resource or data limitations. More detailed methods to develop sub-county projections typically require detailed local knowledge, such as local economic dynamics, planned infrastructure investments, and land-use regulations. For some climate change assessment, sub-county projections can be critical, as in the case of sea level rise (see Text Box 4-7). However, many local governments do not have the data or resources to implement more intensive modeling approaches, and it is an open question as to when and whether knowledge-based projections perform better than more simple techniques (see Text Box 4-8).

Text Box 4-7. Sub-county Population and Sea Level Rise

Population projection methodologies for small area units—namely sub-county units—tend to be less robust than projection methodologies at larger scales. While population is particularly difficult to project at the sub-county level, in some cases the distinctions can be crucial, as in the case of sea level rise, which will have the greatest effects on populations and housing near the coast (which may be only a portion of the county's population). Researchers presenting at the 2014 annual meeting of the Population Association of America developed a methodology for population projection suitable for sub-county units based on two other methods, and demonstrated the method's application by combining it with sea level rise modeling in Coastal Georgia (Hauer, 2014). Research of this type may be instrumental in expanding the available methods for projecting population attributes at the sub-county level.

Participants at the workshop expressed a number of different perspectives on considerations in choosing and applying existing data and modeling approaches. One recurring theme was the importance of “right-scaling.” One participant noted that people have a tendency to think that more resolution is better; in reality, greater resolution may encourage a false sense of precision and accuracy, and may not be necessary for the task at hand. Therefore, “right-scaling” the data and method for what one needs to investigate is an important first step. However, right-scaling can be complicated to determine, when researchers do not have a specific question in mind, but the goal is to develop projections or scenarios that are useful for multiple applications.

Text Box 4-8. How Can We Project the Future at a Sub-county Level?

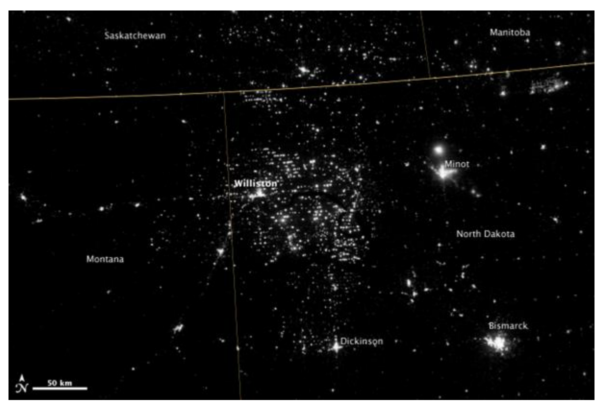
A study in *Demography* (Chi, 2009) focused on the need for more accurate population projections at sub-county levels, as well as a consideration of interactions among population growth, traffic flow, land use, and environmental impacts. The study asked whether more knowledge, especially that of non-demographic factors (such as socioeconomic conditions, transportation accessibility, natural amenities, and geophysical limitations) could improve sub-county population projections. The study found that knowledge *did not* improve population projections at sub-county levels, when compared with statistical and mathematical methods of extrapolation that do not depend on outside knowledge, but also acknowledged that knowledge-based approaches provide other useful information for planners, including the investigation of "what if" scenarios that can be used to devise development and other strategies.

When users have different needs and applications, a flexible approach may be needed. In discussing geographic flexibility (and important difference across user needs), participants considered the usefulness of providing data on a common grid, so that users could move between scales more easily. One participant noted that the United Kingdom and some Scandinavian countries conduct their censuses on a geographical grid. Some participants felt that difficulties with gridded data (e.g., the problem that not all data are available at all scales) could be resolved, while other argued that it is unrealistic to project demographics on a grid, preferring the use of administrative units as the basis of projections. Participants also debated the question of whether it is more appropriate to develop county-level projections and aggregate them, or to develop national/state projections and distribute them downward. In both cases, additional research is needed on resolving differences across scales, particularly in cases where metropolitan areas cross state lines. Last, the discussion also touched on issues of how to provide flexibility in methods across time and geography, with participants making several proposals about how different approaches could be combined to provide coverage over different time scales and/or geographies. Ultimately, incorporating flexibility into a scenario enterprise so that it meets the needs of multiple research communities is a challenging task, and may require using different methods at different scales. More research is needed to understand how to effectively balance these considerations.

Data availability was a key concern for many of the participants. In some cases, data availability limits potential applications. For example, small counties may have insufficient data available for use in structural models, where independent drivers for key variables are needed. Some were concerned about the continued availability of data from the U.S. Census and the American Community Survey due to funding uncertainty. The U.S. Census, for example has not released state projections since 2005. Several participants agreed that a credible set of state-level projections from the Census would be a welcomed resource, as they are the definitive source for data. Offering new options for the future, “big data,” and new forms of private data have the potential to generate new insights, although there are limitations and more work needs to be done to understand the potential in this area (see Text Box 4-9).

Text Box 4-9. New Opportunities and Challenges

There was interest in “big data” and social media, in which some participants saw a potential opportunity to capture data in new ways. For example, cell phone or other records could help capture seasonal or day/night migrations in a way that U.S. Census data cannot. However, there are availability and privacy concerns limiting broader use at this time. Furthermore, they highlight the need to maintain adequate representative sampling, as the population of cell phone users, for example, may behave differently from the rest of the population. It is important to articulate these biases. One presenter also cautioned how new techniques need to be carefully considered. Nighttime light mapping has been used in a number of applications recently, but a night light map of western North Dakota reveals an unusual and extensive pattern of lights that is explained by oil and gas extraction activities, and not permanent urban settlements.



Source: NASA Earth Observatory and NOAA National Geophysical Data Center.

Capabilities: Revisiting the Issues

Particularly at the national level, researchers have many of the capabilities needed to project population and provide support for climate change assessments and policy development and to meet other governmental policy and planning needs. However, researchers do not always have a lot of confidence in these projections, particularly at fine geographic scales and over long time periods, both of which are critical to climate change studies. Moreover, there is a lack of systematic understanding of how non-demographic factors influence population, as well as how to project these factors; if these factors are as important as some researchers believe (see Text Box 4-10), then developing new methods that can project these population characteristics with low uncertainty will be important to developing long-term population projections that meet a variety of user needs.

> **Text Box 4-10. Adding Education as a Standard Demographic Dimension**
>
> Canadian demographer Nathan Keyfitz wrote a famous paper (1981), in which he expressed the view that demographic trends are easier to forecast than many social and economic trends. However, socioeconomic variables may be important to understanding demographic trends, as well as key drivers of impacts or other outcomes (see Text Box 4-4).
>
> A recent paper by Lutz & Skirbekk (2014) provides evidence of a causal relationship between education and health and fertility-related outcomes, making the case that education should be systematically added to age and sex as a third standard demographic dimension.

At larger geographic scales, researchers have confidence in these projection methods and data, but uncertainty increases with smaller geographies and increased demographic detail. One of the presenters at the workshop illustrated the current state of the science using Figure 4-4 (see next page).

In Figure 4-4, the green areas represent the standard demographic variables (age, sex, and race), for which well-understood and commonly applied methods (such as the cohort-component method) exist to project population at the national, state, and even county levels. The yellow cells represent socioeconomic variables, such as health, status, education, and income, which (as described above) are more difficult to project, even at the national level. Going beyond the county level, to develop sub-county projections, presents its own set of complications; many of the methods that can be applied at higher geographic scales break down at the sub-county level, as uncertainty increases at smaller scales.

Figure 4-4. Projection feasibility by population characteristic and geographic resolution